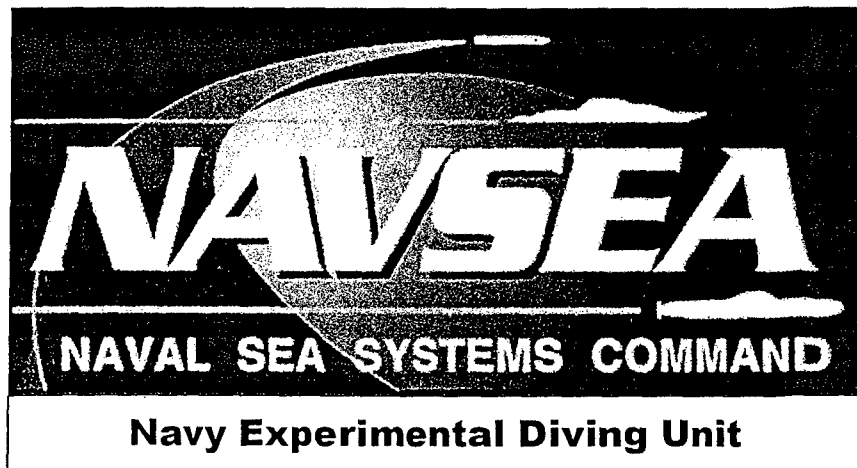


Navy Experimental Diving Unit
321 Bullfinch Rd.
Panama City, FL 32407-7015

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EVALUATION OF OUTLAND TECHNOLOGY, INC.,
SURFACE-SUPPLIED DIVING CAMERA AND LIGHT SYSTEMS
NAVSEA TASKS 01-19 AND 02-10

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Author: Jerry D. Pelton

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INTRODUCTION

As directed by NAVSEA Tasks 02-10 and 01-19, this technical report covers testing of four Outland Technology underwater color television systems, model numbers UWS-3010/D, UWS-3010, UWS-7010, and UWS-7550. Each system consists of a surface control console (SCC) with a videocassette recorder (VCR), a video monitor, and connections for camera(s), light(s), and assorted cables.

The UWS-3010 systems have a line insulation monitor (LIM) and a ground fault circuit interrupter (GFCI) installed for each diver's light. The LIM/GFCI combination offers a new approach for protecting Navy divers and equipment in case of an electrical fault to ground due to a damaged cable or flooded light. To test this approach, procedures were developed to ensure diver safety and reduce damage to equipment if a fault occurred.

The UWS-7010 SCC has an isolation transformer, a GFCI, and a current-limiting circuit installed. This combination provides a level of protection that requires three faults before the diver receives a harmful shock.

The UWS-7550 operates on 12 volts direct current (VDC) power, and in-line fuses protect the diver and equipment. In addition, each internal battery pack has a thermal fuse link that opens when a short circuit occurs. The batteries are nickel-metal hydride (Ni-MH), and the Environmental Protection Agency (EPA) considers them safe and non-hazardous.

All of these systems were tested to determine whether they meet the requirements for being placed on the Authorized for Navy Use (ANU) list of diving equipment.

METHODS

The systems were closely inspected to assess how well they were constructed, how their controls were laid out, how all those controls functioned, and what electrical safety hazards they presented. Technical documentation was reviewed to verify its accuracy and to better understand how each of the system's components works. After reviewing the schematics of the LIM and the GFCI circuits, we determined the proper levels of fault resistance and tested each system to determine its trip times and levels. In addition, all systems were transported via cargo van from Slidell, Louisiana, to Panama City, Florida, with no special handling or extra packing. During transportation and bench testing, parts of MIL-STD 810E (method 514.4 cat. 8, for transportation; method 516.4 procedure VI, for bench handling) were met. Transporting the systems from Panama City to the dive sites via various methods permitted further transportation testing; no failures were reported.

Using NAVXDIVINGUNITINST 3960.3 (Testing Procedure for Ground Fault Interrupter Equipment) as a guideline, we tested the LIM/GFCI circuits. However, this type of

protection circuit required some deviations from the standard test procedures. The LIM/GFCI in these systems ties a resistor to a ground on the return/neutral leg on the secondary side of the isolation transformer; this connection to ground allows the commercial GFCI to work as designed. This circuit's design limits the current flow to ground to no more than 10 ma, even if the light floods or the cable is damaged. The GFCI is designed to trip, within 20 to 30 ms, if a 5 ma leakage to ground occurs. The LIM impresses a low DC voltage (12–15 VDC) onto L1 and L2, and if any imbalance is detected, the LIM causes the GFCI to trip. Since the fault current is below 5 ma, the trip time is 0.3 to 0.4 seconds (300 to 400 milliseconds), and with such a low fault current the long trip time poses no shock hazard to the diver. When the GFCI trips, all power is removed from the cable.

On the UWS-3010, the voltage applied to the light is very close to the variac setting: at 100, the measured voltage at the light is 100 ± 5 volts; at 50, the measured voltage is 50 ± 2 volts. For test purposes we used a fault resistance of 10,100 ohms — which, at 100 VAC, creates a fault current of 9.9 ma; at 50 VAC, a fault current of 4.95 ma; and at 51 VAC, a fault current of 5.05 ma. On the UWS-7010 system, the voltage applied to the light is either 100 percent or 50 percent. Its voltage at 100 percent is 100 ± 2 VAC on L1 and 7 ± 1 VAC on L2; at 50 percent, 50 ± 2 VAC on L1 and 4 ± 1 VAC on L2. The lower voltages on line 2 result from the fault limit circuit.

Controls on all systems were checked for proper function and ease of operation. Connections were tested to ensure that good connections could be made and that labels matched their functions.

Operators from fleet diving units tested all the systems. The UWS-3010D systems provided video coverage during all surface support dives on the *USS Monitor Expedition* 2002, coverage totaling 1,344 hours of video operation per system, 760 hours on each light and 273 hours of recording. The UWS-3010 (single diver), the UWS-7010, and the UWS-7550 were dove on a project in the Puget Sound area of Washington State.

RESULTS

The UWS-3010D provided excellent video coverage of the surface support diving during the *USS Monitor Expedition*. The SCC unit saved space by providing control for two divers, cameras/lights, and two additional video inputs from other diving stations, and it allowed the diving supervisor to track all aspects of diving during the project. The UWS-3010 is electronically identical to the UWS-3010D, except that it provides only one diver camera and light. The UWS-7010 proved to be easy to transport and set up: it operates on 110 VAC from several sources including standard utility power, an inverter powered by an automobile-type battery, and a small, 1000-watt portable generator. The advantage of using the UWS-7010 rather than the UWS-7550 system, which is the same size, is in the UWS-7010's AC-powered light, which provides better coverage. The UWS-7550 is DC-powered via internal batteries or any external 12 VDC source of sufficient amperage. The UWS-7550's advantage over the other systems is in its

portability: it can be easily transported, set up, and dove almost anywhere. Its disadvantages include: its battery life between charges (a little more than two hours per pack, depending on temperature); its limited lighting power (the DC-powered light is low wattage, to increase its battery lifetime); and its limited illumination range, which causes shadows on one side of the picture. The illumination range problem is small and can be corrected with a better light.

DISCUSSION

Some problems were reported with the UWS-3010D systems, which during two months were powered up for a longer time than they would normally have been in a two-year period by most Navy diving facilities. But the problems were minor, and repairs were made on the dive site in most cases. The videotape recorder doors failed after extensive use. Tapes were changed every two hours (a total of more than 130 changes), and at times these were made in a hurry, with little care to avoid damaging the recorder. We are searching for a replacement recorder that can better withstand punishment and is not cost prohibitive.

Only one request for change was made on the other systems tested: to make the light controller on the UWS-7010 and -7550 systems work like that on the UWS-3010 systems. This request is being considered, but such a change poses a space problem, since space available for these systems is very limited in the SCC.

CONCLUSIONS

All the systems tested for this report meet or exceed the safety requirements of International Marine Contractors Association standard, AODC 035, for such equipment. All the systems provided video capabilities as advertised by the manufacturer. The views of underwater objects they provided to operators were often better than those which the divers' eyes could see.

RECOMMENDATIONS

All of the systems covered in this report are recommended for placement on the Authorized for Navy Use (ANU) list. We recommend that diving facilities be allowed to procure these systems and that they be informed that training in operating and maintaining this equipment is available from NEDU staff.

REFERENCE

1. U.S. Naval Sea Systems Command, *Task Assignment 02-10: Evaluation of Outland Technology, Inc., Surface-Supplied Diving Camera and Light Systems*, 23 May 02, and *Task Assignment 01-19: Support for PMS-395*, 29 Aug 01.